(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 253 335 B1**

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: **23.10.91 Bulletin 91/43**

(51) Int. Cl.^{5}: **B32B 27/12**

(21) Application number: **87110017.8**

(22) Date of filing: **10.07.87**

(54) Thermoplastic composite material.

(30) Priority: **16.07.86 US 886543**

(43) Date of publication of application: **20.01.88 Bulletin 88/03**

(45) Publication of the grant of the patent: **23.10.91 Bulletin 91/43**

(84) Designated Contracting States: **AT BE CH DE FR GB IT LI NL SE**

(56) References cited:
EP-A- 0 102 414
FR-A- 1 594 543
FR-A- 2 121 673
FR-A- 2 447 274
US-A- 3 542 616

(73) Proprietor: **Medical Materials Corporation**
31275 La Baya Drive
Westlake Village California 91362 (US)

(72) Inventor: **Fitchmun, Douglas**
24054 Mariano Street
Woodland Hills California 91367 (US)

(74) Representative: **Patentanwälte Grünecker, Kinkeldey, Stockmair & Partner**
Maximilianstrasse 58
W-8000 München 22 (DE)

EP 0 253 335 B1

Description

The present invention relates to a thermoplastic composite material as described in the preamble of claim 1. Such a composite material is disclosed in FR-A-2 447 274.

Specifically the invention relates to a thermoplastic composite material which may be manufactured in sheet or panel form and with the composite material later thermoformed into a complex shape having complex contours. In particular, the complex shape may be used for various industrial or medical purposes and one such specific example is an orthotic insert for use within foot gear.

It is often desirable to form a sheet of plastic material into a complex shape. One method of accomplishing this is to provide for a mold having the desired complex shape and to thermoform the plastic sheet into the complex shape. The thermoforming is typically accomplished through the use of heat and pressure, such as vacuum forming, to conform the plastic sheet to the complex shape. In this type of structure, the plastic sheet would be a thermoplastic material which may be manufactured and sold in sheet form and with a subsequent forming into the complex shape as described above.

As an example, orthotic inserts are currently made using a sheet of acrylic material. The sheet of acrylic material may be cut into a desirable shape and then molded under heat and vacuum to conform to the shape of a casting made in representation of the bottom of a foot. Other thermoplastic materials may be used in substitution to acrylic such as polypropylenes and polyethylenes. The difficulty with all of these materials for use in structures such as orthotics is that, in order to provide the proper level of rigidity necessary to properly serve as an orthotic, these prior art materials are generally quite thick and as an example may vary 3 to 5mm (between 120 to 200 thousandths of an inch). Unfortunately, such thick materials are heavy and are generally too thick to slip into the foot gear already owned. This requires the purchase of larger foot gear to accommodate these prior art orthotic inserts. In addition, the prior art materials are not only thick, but are not as durable and resistant to breaking as would be desirable.

As an alternative to the prior art thermoplastic materials, thermoset laminate constructions have been used to provide for complex shapes such as orthotic inserts. As an example, reference is made to prior Patent No. 4,439,934 issued April 3, 1984, for an orthotic insert. In this patent an insert is formed by a cumbersome technique of laying upon a positive cast a series of layers of various material. These layers may include layers of cloth impregnated with thermoset resin and layers of graphite and with these individual layers thermoset to the desired shape under heat. If the cast is not perfectly accurate, then the insert cannot be adjusted since it has been thermoset (cured) to a specific structural form.

The use of the thermoset process, therefore, means that the orthotic insert must be manufactured to the exact shape the first time since the thermoset process does not allow for any post forming at a later time in the field. This limitation has, therefore, greatly restricted the use of such thermoset laminate constructions as shown in the above referenced patent. It is much more desirable for the person prescribing the orthotic insert to be able to post form the insert to make adjustments to the orthotic insert. This is acomplished through the use of localized heating to make changes in the complex shape of the insert without in turn destroying the structure or integrity of the insert. For these reasons, thermoplastic orthotic inserts have received far greater acceptance in the orthotic field even with the various limitations described above.

It can be seen that a proper combination of features is not available in the prior art. In general the prior art acrylic material is relatively easy to fabricate and is post formable, but this material is typically quite thick, such as 3 to 4.5mm (120 to 180 thousandths of an inch) and is both brittle and heavy. Other prior art materials such as polypropylene are also quite thick, such as 4 to 5mm (160 to 200 thousandths of an inch), but this material is more difficult to fabricate than acrylic and is more difficult to post form. The polypropylene material is heavy, but it is not brittle. The thermoset laminate described above can be quite thin, such as 1.65 to 2mm (65 to 80 thousandths of an inch). However, the fabrication of the thermoset sandwich is difficult and generally requires special processing and once formed is not post formable. The formed thermoset material is not brittle, but even though the material is quite thin it is heavy.

Because of the above described problems with the thermoset laminate construction, complex shapes, such as orthotic inserts, are generally formed using thermoplastic materials, such as acrylic and polypropylene. In particular the insert are made by first making a plaster mold from the patient's foot. This plaster mold forms a negative image of the bottom of the foot. A positive mold is then made from the negative plaster casting and thermoplastic sheet material is thermoformed using heat and vacuum to conform to the positive mold to make the appropriate insert. As indicated above, thermoplastic material has the great advantage in that it is post formable so that the orthotic insert may be heat adjusted at a later time to correct any minor misfit. This is important since it eliminates the necessity of making a new insert as would be necessary with a thermoset laminate construction.

Thus it is an object of the present invention to provide a lightweight, strong and not brittle composite sheet which may be further post-formed.

This object is solved by the features of the characterising clause of claim 1.

The present invention provides for a thermoplastic composite material which overcomes the various difficulties provided by prior art thermoplastic materials and thermoset laminate instruction. Specifically, the thermoplastic composite material of the present invention is relatively thin, such as 1.4 to 2.2mm (55 to 85 thousandths of an inch), is lightweight yet is strong and not brittle. the thermoplastic composite material is easily fabricated into complex shapes such as an orthotic insert and is post formable so that adjustments to the complex shape may be made at a later time.

The above advantages of the present invention are provided by a thermoplastic construction which is a composite and includes a core of a thermoplastic material such as an acrylic and with outside layers of a fabric made from fibers such as carbon fiber, glass fiber, aramid fiber or combinations thereof. The composite construction of the present invention is significantly different than prior art laminate structures in that the fabric layers are located adjacent to the outer surfaces of the composite and with the fiber volume of the fabric layers representing a much smaller fraction of the total volume of the composite than with prior art sandwich constructions. The fabric layers may be woven, unidirectional fibers or chopped or continuous random strand matts or combinations thereof. The direction of the fabric layer may be varied depending upon the desired physical characteristics.

In addition, the core material and other resins used in the construction are thermoplastic materials rather than the thermoset materials of the prior art used in laminate constructions. If the sheet of composite material of the present invention has a particular total volume, then the fiber volume for the fabric layers represents a maximum of one third (1/3) of this total volume. The range for the fiber volume for the fabric layers relative to the total volume of the composite may be between 5% to 33 1/3%, but with the preferred range between 8 to 25%. This is in contrast to the prior art thermoset laminate constructions where the fiber volume of the fabric layers represent more than 50% of the total volume of the laminate construction. As a specific example, a laminate construction using glass fiber fabric typically has the fiber volume of the glass fabric representing 52% to 55% for the total volume of the laminate. If the thermoset laminate uses carbon fabric layers, the fiver volume of the carbon fabric typically represents 55% to 62% of the total volume. As described in the present application, the term fiber volume refers to the volume provided by the sum of the volumes displaced by each individual fiber in the fabric layer. The total volume refers to the overall volume displaced by the composite.

The present invention, therefore, provides for a low percentage of the fiber volume for the fabric layers relative to the total volume and also provides for a specific location of these fabric layers adjacent to the outer surfaces of the sheet of composite material. The location is important since the location maximizes the rigidity of the composite structure when formed to the desired shape. In addition, the relatively large thickness for the core of thermoplastic material between the two fabric layers allows the two layers to move independently of each other during thermoforming. This independent freedom of movement provides for the layers of fabric to conform to the desired complex shape without severe wrinkling or delamination and without any significant buckling of the formed composite material.

If a standard laminate construction were used, or if a higher fiber volume for the fabric layers relative to the total volume were used, the complex shape could not be accomplished without severe wrinkling or delamination and in the extreme case without buckling. As an example, if the composite material of the present invention were constructred with thicker layers of fabric or additional numbers of layers, so that the fiber volume for the fabric layers was more than one third (1/3) of the total volume, then the molded product would have undesirable characteristics such as severe wrinkling and buckling. This does not mean that a composite material constructed in accordance with the teachings of the present invention cannot be made with more than two layers, but rather that the maximum fiber volume of the fabric layers relative to the total volume cannot be more than one third (1/3).

The present invention, therefore, provides for a thermoplastic composite including a core of thermoplastic material and at least two outer layers, adjacent the outside surfaces of the core, to provide for a sheet material which may be thermoformed into a complex shape. The thermoformed shape may be further post formed in order to provide for adjustments to the complex shape. The composite of the present invention is thin, lightweight, rigid and not brittle and is very easy to fabricate.

Brief Description of the Drawing

A clearer understanding of the present invention will be had with reference to the following description and drawings wherein:

Figure 1 is a perspective view of a completed orthotic insert constructed in accordance with the teachings of the present invention;

Figure 2 os a bottom view of the orthotic insert of Figure 1;

Figure 3 is an exploded view of the various materials used to form the thermoplastic composite of the present invention;

Figure 4 is a cross-sectional view of the thermoplastic composite of the present invention

in sheet form and prior to forming into a complex shape;

Figure 5 illustrates a portion of the sheet material of Figure 4 trimmed to a desired configuration, but prior to forming into the complex shape shown in Figures 1 and 2;

Figure 6 illustrates the forming of the sheet material of Figure 5 into the complex shape, but prior to the other steps to produce the completed orthotic insert of Figures 1 and 2;

Figures 7 and 8 illustrate two sides of a composite material after forming and showing the effects of using fabric layers having a maximum fiber volume representing more than one third (1/3) of the total volume; and

Figure 9 illustrates a method of making the thermoplastic composite.

Description of the Preferred Embodiment

Figures 1 and 2 illustrate a completed othotic insert 10 formed by a thermoplastic composite of the present invention. It should be appreciated that the disclosure of the present invention uses an orthotic insert as an example and that the thermoplastic composite of the present invention may also be used for a wide variety of products in the medical and industrial fields.

The orthotic insert 10 is formed by a base member 12 molded from the thermoplastic composite of the present invention. A heel portion 14 is attached to the base member 12 and a soft durable covering material 16 covers the base member 12. The covering material may be of any suitable leather-like material to provide for a comfortable surface adjacent the foot of the user of the orthotic insert. The heel portion 14 may be molded from a rigid plastic material to operate as a heel support within the footgear. Both the heel portion 14 and the covering material 16 are known in the prior art and form no part of the present invention.

Figure 1 also illustrates that the base member 12 formed by the composite has a complex shape conforming to the bottom surface of the foot of the user of the orthotic insert and with each such complex structure tailor made for a particular user. In general the provision of such orthotic inserts is by medical personnel who specialize in fitting such inserts to a user to provide the proper support to the user during various activities. Typically plaster molds of the user's feet are made and these molds are sent to a laboratory. The laboratory in turn makes casting from the molds which casting thereby represents the bottoms of the user's feet. Orthotic inserts are then formed to provide for the proper inserts conforming to the bottoms of the user's feet. The laboratory supplies a finished product, but it is important that this finished product be post formable so that adjustments can be made in the field if there are any problems with the inserts. The base member 12 of composite material of the present invention does allow for such post forming.

As can be seen in Figures 1 and 2, the base member 12 is a composite and includes layers of woven fabric 18 and 20 which are visible at the exterior surfaces of the base member. In particular the layers of woven fabric 18 and 20 are impregnated with thermoplastic material. The composite structure of the base member 12 is formed of a number of layers. As shown in Figure 3 the layers include a central core 22 which represents the thickest portion of the composite structure for the base member 12. Disposed on, and bonded to, the thermoplastic material of the core member 22 are the thermoplastic material impregnating the layers of woven fabric material 18 and 20. Thin layers of thermoplastic material 24 and 26 overlay and impregnate the fabric layers and complete the composite structure. The thermoplastic composite 12 defined by the core 20, the layers of thermoplastic material 22 and 24 the layers of woven fabric 18 and 20 impregnated with the thermoplastic material is formed into a sheet as shown in Figure 4.

The actual production of the thermoplastic composite is shown in Figure 9 and in the first step (a) the layers of woven fabric 18 and 20 are impregnated with a thermoplastic material such as an acrylic prepolymer. The fabric may be formed of carbon fibers, glass fibers or aramid fibers or combinations thereof. Typically the impregnated fabric layers may be then rolled between carrier films for storage. It is to be appreciated that, although the preferred structure for the fabric layer is woven, the fabric layer may also be formed of unidirectional fiber or chopped or continuous random strand matts. The actual composite sheet 12 is then formed as shown in step (b) by stacking a layer of impregnated fabric, a layer of the core such as a core of acrylic material and then a layer of impregnated fabric. As shown in step (c) the structure is then heated under pressure to form the composite 12 shown in Figure 4.

It is to be appreciated that the above method of formation of the composite 12 is illustrative only and other methods may be used. For example, the composite may be formed using a continuous cast technique so that all of the materials are formed together at the same time using separate layers of thermoplastic material, such as acrylic, and separate fabric layers such as carbon, glass or aramid fabric. Also, the particular orientation of the direction of the weave may be varied to adjust the rigidity of the composite.

A significant factor in the formation of the composite is the large thickness of the core layer 22 relative to the fabric layers 18 and 20 and the location of the fabric layers substantially adjacent the outer surfaces of the core layer 22. As a specific example,

in the completed thermoplastic composite sheet of Figure 4, the total thickness may be approximately 70 thousandths of an inch. Each of the fabric layers 18 and 20 may have a thickness of approximately 0.2 to 0.225mm (8 to 9 thousandths of an inch) in the completed composite. The outer layers 24 and 26 of thermoplastic material may be quite thin such as 0.022 to 0.04mm (0.75 to 1.5 thousandths of an inch).

It can be seen, therefore, that the thermoplastic portion represents the majority of the volume of the composite sheet. Specifically, since the fabric layers 18 and 20 are woven and since the thin exterior layers 24 and 26 are bonded to the thermoplastic material impregnating the layers 18 and 20, the actual fiber volume for the fabric layers 18 and 20 represents approximately 13% of the total volume of the composite.

When the fiber volume represents such a small percentage, then the composite may be molded into complex forms without creating any severe wrinkling or buckling of the molded sheet. However, the use of the fabric layers 18 and 20 greatly increases the stiffness and rigidity of the composite relative to a sheet formed only of thermoplastic material. On the other hand, the location of the fabric layers and the relatively large amount of thermoplastic material in the core intermediate the fabric layers allows the layers to move independently of each other during forming so that the layers can adjust to the desired shape.

Prior art thermoset laminate constructions typically used a large number of fabric layers located relatively close to each other, and if such a structure were used even with a thermoplastic material, the structure could not be formed to the desired complex shapes. This is why such prior art laminate constructions are typically formed as a thermoset sandwich where the layers are built up one at a time to individually conform to the desired shape before being thermoset.

Although the described embodiment of a composite has a fiber volume for the layers 18 and 20 of approximately 13% relative to the total volume, the actual range of fiber volume relative to the total volume may be between 5% and 33 1/3% and with a preferred range of 8% to 25%. At the lower percentages the stiffness and rigidity of the composite sheet is reduced while allowing for maximum forming capability. At the higher percentages the stiffness and rigidity are increased while reducing the possible formation capability. The specific embodiment described above provides for the desired rigidity and degree of formation necessary to provide a superior orthotic insert of the type shown in Figures 1 and 2.

Figures 5 and 6 illustrate the methods of manufacture of the orthotic insert of Figures 1 and 2. Specifically in Figure 5 the large panels of composite formed by the method of Figure 9 may be cut into composite sheets 12 having a flat rectangular form. As shown by the dotted line 30, the rectangular form is cut out to represent an orthotic blank 32. This may actually be the blank that would be supplied to the laboratory forming specific orthotic inserts.

In particular as shown in Figure 6, the blank 32 may then be molded by heat and vacuum to conform to the bottom of the foot of a specific user. This is shown by the molded form 34. During the molding the layers of fabric 18 and 20 move to adjust to the complex shape representing the bottom of a foot. Since the fabric layers can move independently of each other, there may only be minor rippling as shown by rippling 36. The rippling represents portions of the fabric being pushed towards each other so that the outer surface of the composite is slightly raised. This rippling 36 is minor and will ultimately be covered by the layer of material 16 shown in Figure 1.

The molded blank 34 of Figure 6 is then turned into a complete orthotic insert by grinding away the outer edge to the specific desired shape and then polishing the edge. A heel member 14 is added either before or after the polishing and finally the inner surface of the insert is covered with the layer of material 16. This is shown in Figures 1 and 2. The completed structure thereby provides the desired rigidity and strength characteristics, but with a much thinner insert than prior art thermoplastic inserts. In addition, the insert of the present invention is post formable so that adjustments may be made to the insert even after the manufacture of the insert in the laboratory.

Figures 7 and 8 represent a molded blank 50 similar to the molded blank 34, but with the fabric layers representing a much higher fiber volume relative to the total volume of the composite material. For example, in the structure of Figures 7 and 8 the fiber volume is greater than one third (1/3) of the total volume and may actually represent over 50% of the total volume. This is the typical fiber volume for thermoset sandwich constructions. As shown in Figures 7 and 8, the high fiber volume molded blank 50 includes major rippling such as the rippling shown at position 52, but even worse includes buckled portions such as the buckled portions 54 shown on the inside and outside of the molded structure in Figure 7 and 8. These buckled portions result from a failure of the fabric material to properly move relative to each other which produces a locking of the sheet material during molding. This locking can only be relieved by severe folds such as the buckled portions 54. Actually if the volume of fiber material is greater than 50% of the total volume then sometimes it is not even possible to produce a molded product since the high amount of fiber material completely resists molding into a desired shape. As will be appreciated, the arrangement shown in Figures 7 and 8 does not constitute an embodiment of the invention.

The present invention, therefore, provides for a thermoplastic composite which may be formed into complex structural shapes and produce a resultant structure which is rigid, relatively thin and lightweight. The composite material may be post formed so as to provide for adjustments or corrections in the molded product. Although the invention has been described with reference to a particular embodiment and specifically an orthotic insert, in is to be appreciated that the thermoplastic composite of the present invention may have other industrial or medical uses.

Claims

1. A thermoplastic thermoformable composite sheet for shaping into a form, including a core (22) of a thermoplastic material formed as a sheet, and two layers of another material respectively positioned at opposite surfaces of the core (22) of the thermoplastic material, the thickness of the core (22) representing a substantial portion of the particular thickness of the composite sheet, **characterised in that** the two layers (18,20) are of fabric material and are sealed to such thermoplastic material, that the fiber volume of the at least two layers (18,20) of fabric material represents less than one third (1/3) of the particular volume of the composite sheet, and that the core (22) of the thermoplastic material is provided with a thickness to provide for a movement of the layers (18,20) of the sheet independently of one another during shaping of the sheet into the complex form without rippling or buckling of the layers (18,20).

2. The thermoplastic thermoformable composite sheet of claim 1, characterized by two layers (24,26) of thermoplastic resin material each disposed on one of the two layers (18,20) of fabric material to form an outer covering for protecting the layers (18,20) of the fabric material and for providing a smooth exterior adhered to the overlayed layer of fabric material.

3. The thermoplastic thermoformable composite sheet of claim 1 or 2 wherein the two layers (24,26) of thermoplastic resin material overlaying the layers (18,20) of fabric material are formed by impregnating the fabric material with the thermoplastic resin.

4. The thermoplastic thermoformable composite sheet of one of claims 1 to 3, wherein the thermoplastic material is an acrylic.

5. The thermoplastic thermoformable composite of one of claims 1 to 4, wherein the two layers (18,20) of the fabric material are made of fibers selected from the group consisting of carbon, glass and aramid.

6. The thermoplastic thermoformable composite sheet of one of claims 1 to 5, wherein the two layers (18,20) of the fabric material are selected from the group consisting of woven fibers, undirectional and chopped fibers and random strand mats.

7. The thermoplastic thermoformable composite sheet on one of claims 1 to 6, wherein the two layers (18,20) of the fabric material are woven.

8. The thermoplastic thermoformable composite sheet of one of claims 1 to 7, wherein the fiber volume of the two layers (18,20) of the fabric material is within a range of five (5) to thirty three and one third (33 1/3) percent of the total volume of the composite.

9. The thermoplastic thermoformable composite sheet of one of claims 1 to 8, wherein the fiber volume of the two layers (18,20) of the fabric material is within a range of eight (8) to twenty five (25) percent of the total volume of the composite.

10. The thermoplastic thermoformable composite sheet of one of claims 3 to 9 wherein the thickness of the two layers (24,26) of thermoplastic resin bonded to the thermoplastic material impregnating the layers of fabric is relatively small compared to the thickness of the core of thermoplastic resin material.

11. The thermoplastic thermoformable composition sheet of one of claims 2 to 10, wherein the thickness of the core (22) is greater than the thickness of each of the layers (18,20) of the fabric material and wherein the thickness of each of the layers (18,20) of fabric material is greater than the thickness of the two layers (24,26) of thermoplastic resin material.

12.An orthotic insert formed by shaping into a contoured form the thermoplastic thermoformable composite sheet of one of claims 1 to 10.

13. The orthotic insert of claim 12, having a heel portion (14) and a base member (12) and wherein a soft and durable material (16) covers the base member, the heel portion being molded from a rigid plastic material to operate as a heel support.

14. A method of forming a thermoplastic thermoformable composite sheet according to one of claims 1 to 13 including the following steps, providing two layers (18,20) of fabric material, each having a thickness less than the particular thickness of the composite sheet, providing a core (22) of a thermoplastic resin between the two layers (18,20) of fabric material in a thickness greater than the thickness of the layers (18,20) of the fabric material, and simultaneously applying heat and pressure to the layers of the fabric material and the core to form the layers (18,20) of the fabric material and the core (22) in a composite sheet in which the volume of the two layers of the fabric material represents less than one third (1/3) of the total volume of the composite sheet.

15. The method of claim 14 including the additional step of providing two additional layers (24,26) of the thermoplastic resin overlaying the layers of the fabric material, the step of forming the layers (18,20) of the fabric material and the core (22) into the composite sheet also involving the formation of the two additional layers (24,26) into the composite sheet by impregnating the layers of fabric material with the thermoplastic resin.

16. The method of claim 15, wherein the composite sheet is formed by the imposition of heat and pressure simultaneously on the core (22) of the thermoplastic resin, the two layers (18,20) of the fabric material and the two additional layers (24,26) of the thermoplastic resin.

17. The method of one of claims 14 to 16, wherein the composite sheet is formed by heat and pressure to fuse the various layers (18,20,22,24,26) together.

18. The method of one of claims 14 to 17 additionally including the step of molding the composite sheet into an orthotic insert.

Patentansprüche

1. Thermoplastisches wärmeverformbares Verbundflachmaterial zum Verformen in einer Form, mit einem Kern aus thermoplastischem Material in Blattform und zwei Schichten eines anderen Materials, die auf den sich gegenüberliegenden Seiten des Kerns (22) aus thermoplastischem Material angeordnet sind, wobei die Dicke des Kerns (22) einen wesentlichen Anteil der besonderen Dicke des Verbundflachmaterials ausmacht, **dadurch gekennzeichnet,** daß die beiden Schichten (18, 20) aus Stoff sind und so auf das thermoplastische Material aufgelegelt sind, daß die Faservolumen der mindestens zwei Schichten (18, 20) weniger als ein Drittel (1:3) des Gesamtvolumens des Verbundflachmaterials beträgt, und daß der Kern (22) des thermoplastischen Materials eine Dicke aufweist, die während des Formens des Verbundmaterials in einer komplexen Form eine unabhängige Bewegung der beiden Schichten (18, 20) gegeneinander gestattet, ohne dabei die Schichten (18, 20) zu kräuseln oder zu knicken.

2. Thermoplastisches wärmeverformbares Verbundflachmaterial nach Anspruch 1, gekennzeichnet durch zwei Schichten (24, 26) aus thermoplastischem Kunststoffmaterial, wovon jeweils eine auf einer der beiden Schichten (18, 20) aus Stoff angeordnet ist, um eine äußere Abdeckung zum Schutz der Schichten (18, 20) aus Stoff zu bilden, und um ein glattes, mit der überdeckten Stoffschicht verbundenes Äußeres vorzusehen.

3. Thermoplastisches wärmeverformbares Verbundflachmaterial nach Anspruch 1 oder 2, wobei die beiden die Stoffschichten (18, 20) überdeckenden Schichten (24, 26) aus thermoplastischem Kunststoffmaterial dadurch gebildet sind, daß das Stoffmaterial mit thermoplastischem Kunststoff imprägniert ist.

4. Thermoplastisches wärmeverformbares Verbundflachmaterial nach einem der Ansprüche 1 bis 3, wobei das thermoplastische Material Acryl ist.

5. Thermoplastisches wärmeverformbares Verbundflachmaterial nach einem der Ansprüche 1 bis 5, wobei die beiden Stoffschichten (18, 20) aus Fasern hergestellt werden, die aus der Gruppe der Carbonfasern, der Glasfasern und Aramidfasern ausgewählt sind.

6. Thermoplastisches wärmeverformbares Verbundflachmaterial nach einem der Ansprüche 1 bis 5, wobei die beiden Stoffschichten (18, 20) aus der Gruppe gewebter Fasern, unidirektionaler und Wirrfasermatten ausgewählt ist.

7. Thermoplastisches wärmeverformbares Verbundflachmaterial nach einem der Ansprüche 1 bis 6, wobei die beiden Stoffschichten (18, 20) gewebt sind.

8. Thermoplastisches wärmeverformbares Verbundflachmaterial nach einem der Ansprüche 1 bis 7, wobei das Faservolumen der beiden Stoffschichten (18, 20) innerhalb eines Bereichs von fünf (5) bis dreiunddreißig ein Drittel (33 1/3) % des Gesamtvolumens des Verbundmaterials liegt.

9. Thermoplastisches wärmeverformbares Verbundflachmaterial nach einem der Ansprüche 1 bis 8, wobei das Faservolumen der beiden Stoffschichten (18, 20) innerhalb eines Bereichs von acht (8) bis fünfundzwanzig (25) % des Gesamtvolumens des Verbundmaterials liegt.

10. Thermoplastisches wärmeverformbares Verbundflachmaterial nach einem der Ansprüche 3 bis 9, wobei die Dicke der beiden Schichten (24, 26) aus thermoplastischem Kunststoff, die an dem thermoplastischen Material haften, das die Stoffschichten imprägniert, relativ gering ist verglichen mit der Dicke des Kerns aus thermoplastischem Kunststoff.

11. Thermoplastisches wärmeverform res Verbundflachmaterial nach einem der Ansprüche 2 bis 10, wobei die Dicke des Kerns (22) größer ist als die Dicke jeder der beiden Stoffschichten (18, 20) und wobei die Dicke jeder der beiden Stoffschichten (18,-20) größer ist als die Dicke der beiden Schichten (24, 26) aus thermoplastischem Kunststoff.

12. Orthopädische Einlage, hergestellt durch Einformen eines thermoplastischen wärmeverformbaren Verbundflachmaterials nach einem der Ansprüche 1 bis 10, in eine konturierte Form.

13. Orthopädische Einlage nach Anspruch 12, mit einem Fersenabschnitt (14) und einem Basisteil (12), wobei ein weiches und dauerhaftes Material (16) das Basisteil abdeckt und der Fersenabschnitt aus einem starren Kunststoffmaterial geformt ist, um als Fersenstütze zu wirken.

14. Verfahren zum Herstellen eines thermoplastischen wärmeverform ren Verbundflachmaterials nach einem der Ansprüche 1 bis 13, umfassend die folgenden Schritte: Vorsehen zweier Schichten (18,-20) aus Stoffmaterial, von denen jede eine geringere Dicke aufweist als die besondere Dicke des Verbundmaterials, Vorsehen

eines Kerns aus thermoplastischem Kunststoff zwischen den beiden Stoffschichten (18, 20) in einer Dicke, die größer ist als die Dicke der beiden Stoffschichten (18, 20), und gleichzeitiges Aufbringen von Wärme und Druck auf die beiden Stoffschichten und den Kern, um die Stoffschichten (18, 20) und den Kern (22) in ein Verbundmaterial zu formen, bei dem das Volumen der beiden Stoffschichten weniger als ein Drittel (1:3) des Gesamtvolumens des Verbundmaterials ausmacht.

15. Verfahren nach Anspruch 14, umfassend den zusätzlichen Schritt des Vorsehens zweier zusätzlicher thermoplastischer Kunststoffschichten (24, 26), die die beiden Stoffschichten überlappen, wobei der Schritt des Formens der Stoffschichten (18, 20) und des Kerns (22) in das Verbundflachmaterial auch das Anordnen der beiden zusätzlichen Schichten (24, 26) auf dem Verbundflachmaterial durch Imprägnieren der Stoffschichten mit dem thermoplastischen Kunststoff beinhaltet.

16. Verfahren nach Anspruch 15, wobei das Verbundflacchmaterial hergestellt ist durch das Anwenden von Wärme und Druck gleichzeitig auf den Kern (22) aus thermoplastischem Kunststoff, die beiden Stoffschichten (18, 20) und die beiden zusätzlichen Schichten (24, 26) aus thermoplastischem Kunststoff.

17. Verfahren nach einem der Ansprüche 14 bis 16, wobei das Verbundflachmaterial hergestellt ist, indem durch Hitze und Druck die verschiedenen Schichten (18, 20, 22, 24, 26) zuzsammengeschmolzen werden.

18. Verfahren nach einem der Ansprüche 14 bis 17 zusätzlich mit dem Schritt des Formens des Verbundflachmaterials zu einer orthopädischen Einlage.

Revendications

1. Feuille thermoplastique thermoformable composite pour façonnage en une forme, comprenant une âme (22) en matériau thermoplastique sous forme de feuille, et deux couches d'un autre matériau respectivement disposées sur des surfaces opposées de l'âme (22) du matériau thermoplastique, l'épaisseur de l'âme (22) représentant une partie notable de l'épaisseur particulière de la feuille composite, caractérisée en ce que les deux couches (18, 20) sont faites de tissu et sont scellées à ce matériau thermoplastique, en ce que le volume de fibre d'au moins les deux feuilles (18, 20) de tissu représente moins d'un tiers (1/3) du volume particulier de la feuille composite, et en ce que l'âme (22) du matériau thermoplastique présente une épaisseur autorisant un mouvement des couches (18, 20) de la feuille indépendamment l'une de l'autre lors du façonnage de la feuille en une forme complexe sans ondulation ni gauchissement des couches (18, 20).

2. Feuille thermoplastique thermoformable composite selon la revendication 1, caractérisée par deux couches (24, 26) de matériau thermoplastique résineux, chacune déposée sur l'une des deux couches (18, 20) du tissu pour former un revêtement pour protéger les couches (18, 20) du tissu et pour conférer un extérieur lisse adhérant à la couche de tissu superposée.

3. Feuille thermoplastique thermoformable composite selon la revendication 1 ou 2, dans laquelle les deux couches (24, 26) de matériau thermoplastique résineux superposées aux couches (18, 20) de tissu sont formées par imprégnation du tissu avec la résine thermoplastique.

4. Feuille thermoplastique thermoformable composite selon l'une des revendications 1 à 3, dans laquelle le matériau thermoplastique est une résine acrylique.

5. Feuille thermoplastique thermoformable composite selon l'une des revendications 1 à 4, dans lequelle les deux couches (18, 20) de tissu sont faites de fibres sélectionnées dans le groupe constitué par les fibres de carbone, de verre et d'aramide.

6. Feuille thermoplastique thermoformable composite selon l'une des revendications 1 à 5, dans laquelle les deux couches (18, 20) de tissu sont faites de fibres sélectionnées dans le groupe constitué par des fibres tissées, des fibres unidirectionnelles et hachées et des mats de filaments aléatoires.

7. Feuille thermoplastique thermoformable composite selon l'une des revendications 1 à 6, dans laquelle les deux couches (18, 20) de tissu sont tissées.

8. Feuille thermoplastique thermoformable composite selon l'une des revendications 1 à 7, dans laquelle le volume de fibres des deux couches (18, 20) de tissu se situe dans l'intervalle de cinq (5) à trente-trois et un tiers (33 1/3) pour cent du volume total du composite.

9. Feuille thermoplastique thermoformable composite selon l'une des revendications 1 à 8, dans laquelle le volume de fibres des deux couches (18, 20) de tissu se situe dans l'intervalle de huit (8) à vingt cinq (25) pour cent du volume total du composite.

10. Feuille thermoplastique thermoformable composite selon l'une des revendications 3 à 9, dans laquelle l'épaisseur des deux couches (24, 26) de la résine thermoplastique liée au matériau thermoplastique imprégnant les couches de tissu, est relativement faible par comparaison à l'épaisseur de l'âme de matériau thermoplastique résineux.

11. Feuille thermoplastique thermoformable composite selon l'une des revendications 2 à 10, dans laquelle l'épaisseur de l'âme (22) est supérieure à l'épaisseur de chacune des couches (18, 20) de tissu et dans laquelle l'épaisseur de chacune des couches (18, 20) de tissu est supérieure à l'épaisseur des deux

couches (24, 26) de matériau thermoplastique résineux.

12. Insert orthopédique formé par façonnage en une forme adaptée au corps humain, de la feuille thermoplastique thermoformable composite selon l'une des revendications 1 à 10.

13. Insert orthopédique selon la revendication 12, ayant une partie de talon (14) et un élément de base (12), et dans lequel un matériau mou et durable (16) recouvre l'élément de base, la partie de talon étant moulée à partir d'un matériau plastique rigide pour jouer le rôle d'un support de talon.

14. Procédé de formation d'une feuille thermoplastique thermoformable composite selon l'une des revendications 1 à 13, comprenant les étapes suivantes : fournir deux couches (18, 20) de tissu, chacune ayant une épaisseur inférieure à l'épaisseur particulière de la feuille composite, réaliser une âme (22) en résine thermoplastique entre les deux couches (18, 20) de tissu sur une épaisseur supérieure à l'épaisseur des couches (18, 20) de tissu, et appliquer simultanément de la chaleur et une pression aux couches de tissu et à l'âme pour transformer les couches (18, 20) du tissu et l'âme (22) en une feuille composite dans laquelle le volume des deux couches de tissu représente moins d'un tiers (1/3) du volume total de la feuille composite.

15. Procédé selon la revendication 14, comprenant l'étape supplémentaire consistant à réaliser deux couches supplémentaires (24, 26) de résine thermoplastique superposées aux couches de tissu, l'étape de transformation des couches (18, 20) de tissu et de l'âme (22) en la feuille composite impliquant également la transformation des deux couches supplémentaires (24, 26) en la feuille composite par imprégnation des couches de tissu avec la résine thermoplastique.

16. Procédé selon la revendication 15, dans lequel la feuille composite est transformée par exposition simultanée de l'âme (22) de la résine thermoplastique, des deux couches (18, 20) de tissu et des deux couches supplémentaires (24, 26) de résine thermoplastique, à de la chaleur et à une pression.

17. Procédé selon l'une des revendications 14 à 16, dans lequel la feuille composite est formée par exposition à de la chaleur et à une pression pour faire fusionner les diverses couches (18, 20, 22, 24, 26) les unes aux autres.

18. Procédé selon l'une des revendications 14 à 17, comprenant en outre l'étape consistant à mouler la feuille composite en un insert orthopédique.

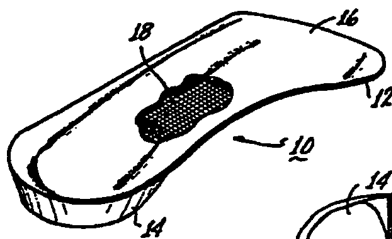

Fig.1

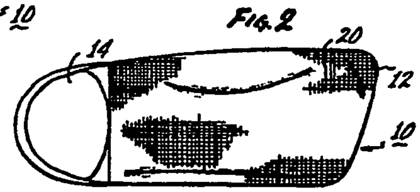

Fig.2

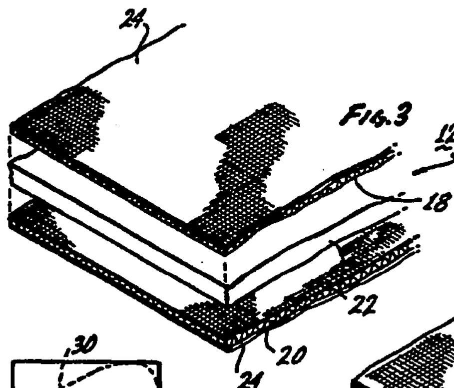

Fig.3

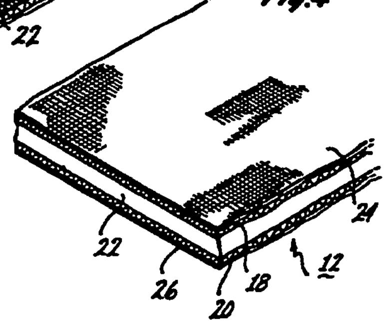

Fig.4

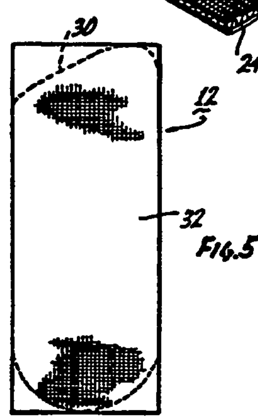

Fig.5

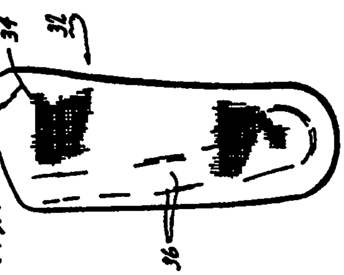

Fig. 6

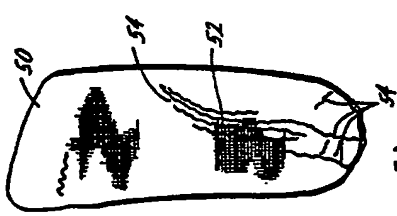

Fig. 7

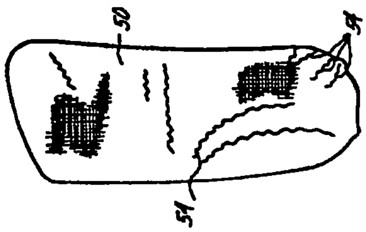

Fig. 8

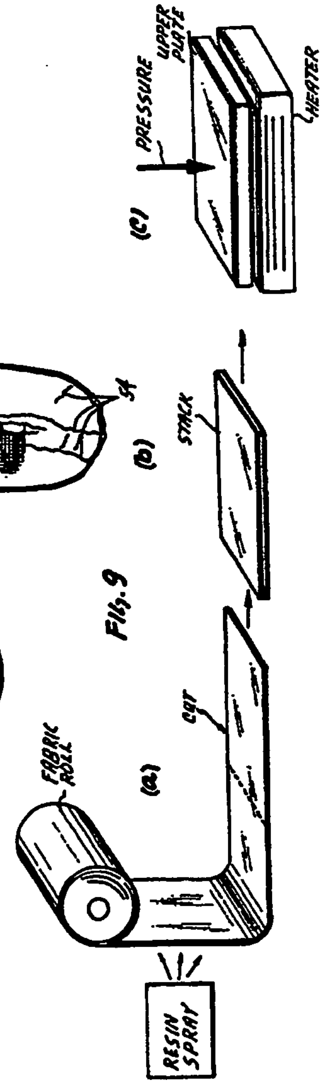

Fig. 9